Development of Universal Design Mobile Interface Guidelines (UDMIG) for Aging Population

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Abstract. The number of older adults using technology is steadily increasing. However, this group of users has faced a variety of user interface (UI) usability issues due to various and multiple age-related limitations they have. Four different strategies designed to solve the usability issues older adults have while interacting with user interfaces were analyzed. When placed in a context of mobile interfaces for older adults, Universal Design (UD), Design for Aging, Universal Usability (UU), and Guidelines for handheld mobile device interface design were not found sufficiently complete and inclusive to meet the usability needs of older adults. There is a need to address these usability needs and reconcile inconsistencies between the four strategies. The purpose of this research study was to develop a robust, integrative set of design guidelines based on the four design strategies to ensure usability of mobile devices by older adults. An example of the application of the guidelines to the mobile interface is presented in the paper.

Keywords: Accessibility guidelines · Design for aging · Human factors · Older adults · Universal design · User interface design

1 Introduction

As the population ages, more older adults are becoming technology users [1]. However, many older adults experience declines in one or more abilities, including reduction in ranges and levels of abilities, such as vision, cognition and dexterity, that can limit their ability to use and interact with technology user interfaces (UIs). Common problems include an inability to understand common icons, taking a long time to complete a task or having poor task performance, making an inordinate number of errors, having difficulty in seeing text, and having problems understanding the relationship between the touchscreen and button manipulation with the response of the interface [2–4]. Despite these issues, product and user interface design can help older adults by incorporating their particular sensory-perception, motor, communication, and mental needs into the design of the interfaces [5].

M. Antona and C. Stephanidis (Eds.): UAHCI 2016, Part I, LNCS 9737, pp. 98–108, 2016.
DOI: 10.1007/978-3-319-40250-5_10

To address issues of usability of UIs by older adults and others with functional limitations, a number of different design strategies have been proposed. Four of the most widely accepted strategies were analyzed as part of this project: Universal Design, Design for Aging, Universal Usability, and Guidelines for handheld mobile device interface design. Universal Design (UD) [6] is a strategy that supports the diverse ranges and combinations of abilities and limitations that characterize this population of users. The purpose of UD is to design for everyone and by doing so, to overcome the barriers to usability that come with aging [7]. In contrast to UD, Design for Aging [8] focuses on older adults' specific and singular limitations. Design for Aging is a strategy that explores the factors that constrain the use of products and user interfaces by older adults, as well as aspects of human-computer interface design that accommodate older users with age-associated disabilities and limitations [9]. Based on UD, which was initially intended to cover design of physical environments (e.g. buildings, spaces, products, graphics), Universal Usability (UU) was developed to support usability, inclusivity, and utility of information and communication technology [10]. It consists of the eight guidelines, called the Eight Golden Rules of Interface Design. Guidelines for handheld mobile device interface design [11] were based on UU, modifying its Eight Golden Rules of Interface Design and adding the guidelines applicable to mobile and touchscreen platforms (See Table 1).

Table 1. Four strategies' specific domains and types of users

Strategies	Specific Domains	Types of Users
Universal Design	Physical environments (e.g. buildings, spaces, products, graphics)	All users
Design for Aging	Technology systems and products (e.g. computer input and output devices, desktop interfaces, helathcare technologies), environments (e.g. lighting, navigational signage), work tasks, and training and instructional programs	Older adults
Universal Usability	Information and communication technology (desktops)	All users
Guidelines for handheld mobile device interface design	Mobile and touchscreen devices	All users

When placed in a context of mobile interfaces for older adults none of these four strategies alone were sufficiently complete and inclusive to meet the range and diversity of usability needs of older adults. To address these usability needs and reconcile inconsistencies among the four strategies, a robust, integrative set of guidelines to ensure usability of mobile devices by older adults was developed. This paper reviews the development and content of the Universal Design Mobile Interface Guidelines (UDMIG), which is based on the four strategies, the extension of the original guidelines into a more comprehensive, inclusive set of design guidelines and details the results of a project to design a mobile interface based on these guidelines [12].

2 Development Process of Universal Design Mobile Interface Guidelines (UDMIG)

The first version of the guidelines, UDMIG v.1.0, which has been previously reported [13], was created by applying Design for Aging, Universal Usability, and Guidelines for handheld mobile device interface design to Universal Design guidelines and its seven principles. UDMIG v.1.0 was developed by expanding the UD principles and guidelines to include components of the other three sets of guidelines. Universal Design was kept as an organizing strategy because of its broad application, inclusiveness, and consideration of all users' ranges and combinations of abilities from the beginning of the design process [14, 15].

However, UDMIG v.1.0 were too simplistic and were based too much on the UD Principles. As a result, they needed further refinement. We further developed and grouped all four design guidelines anew based on the two organizing principles: Person-Environment (P-E) Fit Model [16] and the Guideline Objective as being Prescriptive- vs. Performance-based (See Table 2).

P-E Fit Model. P-E Fit defines the degree to which individual and environmental characteristics match in order to promote healthy aging. Both UDMIG and P-E Fit Theory explore the interaction between aging individuals and their environments [17]. The P-E Fit model examines the match or fit between the competence (or functional ability) of a person and demand of the environment component. When there is a match between person and environment usability is achieved [18]. However, barriers in the environment can create different types and levels of usability problems depending on a person's functional capacity [19].

Here, the person component is a part of all the guidelines, which all describe how to accommodate people with different abilities. The environment component includes the guidelines that describe the design of the touchscreen mobile interface as well as the space requirements and context of use. It is divided into two parts: Micro Environment guidelines (e), which represent those that pertain to the design of the interactive mobile interface, and Macro Environment guidelines (E), which describe guidelines that direct the design of space and context in which the mobile interface is used. The fit (F) component includes the guidelines that guide the design of the interaction between the older adult and the touchscreen mobile interface (See Table 2).

Prescription vs. Performance. The four strategies were also grouped into the prescription vs. performance guidelines. Performance-based guidelines suggest how design can meet the usability goals and objectives without prescribing what to do. In contrast, prescriptive guidelines specify what should be designed to achieve usability. Only several Design for Aging guidelines are prescriptive, while the other three strategies, including the resulting UDMIG v.2.0, are performance guidelines in whole. In addition, a number of Design for Aging guidelines are both performance and prescriptive (See Table 2).

Table 2. The guidelines from the four strategies with the resulting UDMIG v.2.0

Data						Results	
Prescriptive D.Guidelines	**Prescriptive/ Performance**	**Performance Design Guidelines**					
Design for Aging			**Guidelines for handheld mobile device interface design**	**Universal Usability**	**Universal Design**	**Universal Design Mobile Interface Guidelines**	
DFA1.2.4 50:1 contrast DFA1.3.1 3D and VR displays DFA2.2.2 Speech rates DFA2.2.4 Longer duration sounds	DFA1.2.2 Style sheets DFA2.1.1. Sound volumes; instructions DFA4.2.6 Resolution DFA4.2.7 Built-in controls DFA5.2.3 Search history DFA5.2.5 Navigation assistance DFA5.4.1 Standardized format DFA5.4.3 Current system status DFA5.4.4 Feedback	DFA1.2.5 Color discriminations DFA4.1.1 Default values or profiles DFA4.2.8 Adjustable output sound intensity DFA5.1.1 Clutter DFA5.1.2 Adaptability DFA5.1.4 Characters and targets DFA5.2.4 Where the user is DFA5.3.1 Information organization DFA5.3.2 Menu structure DFA5.3.3 Frequent important actions DFA5.4.2 Compatibility DFA5.4.5 Error correction, recovery DFA5.4.6 System tools DFA5.4.7 User levels	MD1. Shortcuts MD3. Dialogs to yield closure MD4. Locus of control MD5. Consistency (platforms) MD7. Error prevention, handling MD8. Short-term memory load MD9. Multiple dynamic contexts MD10. Small devices MD11. Limited and split attention MD12. Speed and recovery MD14. Personalization	UU1. Consistency UU4. Dialogs to yield closure UU5. Error handling UU7. Locus of control UU8. Short-term memory load	UD1a. Same means of use UD1b. Segregating/stigmatizing users UD1c. Privacy, security, and safety available to all UD2a. Choice in methods of use UD2b. Right- or left-handed access/use UD2c. Accuracy and precision UD2d. Adaptable pace UD3b. Consistency UD3c. Range of literacy/language skills UD5a. Hazards and errors UD5d. Unconscious action UD6a. Neutral body position	F1. Same means of use F2. Range of literacy and language skills F3. Choice in methods of use F4. Support of the internal locus of control F5. Right-, left- or no-handed use F6. Accuracy and precision F7. Adaptable pace F8. Consistency with expectations and intuition F9. Dialogs that yield closure F10. Clear and understandable navigation structure F11. Multiple and dynamic contexts F12. Minimized hazards and unintended actions F13. Natural body position	Fit (Person-Environment Interaction) - F
DFA1.2.1Font size DFA1.2.3 Font type DFA1.2.4 50:1 contrast DFA2.1.2 Frequency > 4000Hz DFA2.1.3 Warning signals DFA3.1.1 Haptic processing DFA4.2.2 Size of the text DFA Auditory warnings	DFA2.2.3 Voice characteristics-situation DFA3.1.2 Upper to lower body sites-vibration DFA4.1.2 Avoid double-clicking DFA4.1.5 Speech recognition control DFA4.1.8 Tactile and auditory feedback DFA4.2.5 Instructions on resolution DFA4.2.9 Warning message DFA4.2.10 Tactile output devices DFA5.2.2 Site map DFA5.4.4 Feedback	DFA1.2.5 Color discriminations DFA1.2.6, DFA5.2.1 Scrolling DFA2.1.4 Redundant information DFA2.1.5 Background noise and reverberation DFA2.2.1 Pauses in speech DFA4.1.7 Large keypad keys DFA4.2.1 Contrast DFA5.1.1 Clutter DFA5.1.3 Temporal constraints DFA5.1.4 Characters and targets DFA5.3.1 Information organization DFA5.3.2 Menu structure DFA5.3.3 Frequent important actions DFA5.4.5 Error correction, recovery	MD2. Feedback MD4. Locus of control MD5. Consistency (platforms) MD6. Reversal of actions MD7. Error prevention, handling MD8. Short-term memory load MD10. Small devices MD11. Limited and split attention MD13. "Top-down" interaction MD15. Enjoyment	UU1. Consistency UU3. Informative feedback UU5. Error handling UU6. Reversal of actions UU7. Locus of control UU8. Short-term memory load	UD1d. Appealing design UD3a. Eliminate complexity UD3d. Information consistent with importance UD3e. Prompting and feedback UD4a. Different modes UD4b. Contrast UD4c. "Legibility" of information UD4d. Differentiate elements UD4e. Compatibility with techniques/devices UD5b. Warnings of hazards/errors UD5c. Fail-safe features UD7c. Variations in hand/grip size UD6b. Operating forces UD6c. Repetitive actions UD6d. Sustained physical effort	e1. Design appealing to all e2. Simple and natural use e3. Informative feedback e4. Use of different modes e5. Maximized "legibility" of essential information e6. Simple error handling e7. Easy reversal of actions e8. Low physical effort e9. Variations in hand and grip size	Micro Environment - e
	DFA1.1.2 Non-reflectant materials DFA1.1.2 Adj. light sources DFA4.2.3 Glare DFA4.2.4 Adj. display	DFA1.1.1 Illumination DFA2.1.5 Background noise/reverberation DFA4.1.10 "Homing"			UD7a. Clear line of sight UD7b. Reach to components UD7d. Space for assistive devices	E1. Appropriate lighting and glare E2. Adjustable positioning E3. Minimized background noise and reverberation E4. Space for use of assistive devices	Macro Environment-E

3 Results

3.1 Cross-Walking the Guidelines

To develop a second version of the UDMIG, the four design strategies were cross-walked and categorized by the P-E Fit and Performance/Prescriptive dimensions. Equivalent guidelines from each of the four strategies were mapped onto each other, while unique guidelines were added to the final set to create UDMIG v.2.0 (See Table 3.).

Table 3. UDMIG v.2.0 performance – prescriptive guidelines crosswalk

Prescriptive D.Guidelines	Prescriptive/ Performance	Performance Design Guidelines					
Design for Aging			Guidelines for handheld mobile device interface design	Universal Usability	Universal Design	Universal Design Mobile Interface Guidelines	
DFA1.2.4 (F6) DFA1.3.1 (F6) DFA2.2.2 (F7) DFA2.2.4 (F11)	DFA1.2.2 (F6) DFA2.1.1 (F6); (F3) DFA4.2.6 (F6) DFA4.2.7 (F11) DFA5.2.3 (F9,F10) DFA5.2.5 (F10) DFA5.4.1 (F8) DFA5.4.3 (F9) DFA5.4.4 (F9)	DFA1.2.5 (F6) DFA4.1.1 (F11) DFA4.2.8 (F11) DFA5.1.1 (F6) DFA5.1.2 (F11) DFA5.1.4 (F6,F7) DFA5.2.4 (F9) DFA5.3.1 (F9) DFA5.3.2 (F6,F9) DFA5.3.3 (F12) DFA5.4.2 (F8,2) DFA5.4.5 (F12) DFA5.4.6 (F4,F6,F7,F8) DFA5.4.7 (F6)	MD1. (F7) MD3. (F9) MD4. (F4) MD5. (F8) MD7. (F12) MD8. (F6) MD9. (F11) MD10. (F3) MD11. (F3,F5) MD12. (F7) MD14.(F2,F3,F6, F7,F11)	UU1. (F8) UU4. (F9) UU5. (F12) UU7. (F3, F4) UU8. (F6)	UD1a. (F1) UD1b. (F1) UD1c. (F1) UD2a. (F3) UD2b. (F5) UD2c. (F6) UD2d. (F7) UD3b. (F8) UD3c. (F2) UD5a. (F12) UD5d. (F12) UD6a. (F13)	F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13	Fit - F
DFA1.2.1 (e5) DFA1.2.3 (e5) DFA1.2.4 (e5) DFA2.1.2 (e3) DFA2.1.3 (e6) DFA3.1.1 (e4) DFA4.2.2 (e5) DFA4.2.11 (e6)	DFA2.2.3 (e5) DFA3.1.2 (e4) DFA4.1.2 (e8) DFA4.1.5 (e4,e5) DFA4.1.8 (e4) DFA4.2.5 (e5) DFA4.2.9 (e3,e6) DFA4.2.10 (e4) DFA5.2.2 (e5) DFA5.4.4 (e3)	DFA1.2.5 (e2,e5) DFA1.2.6, DFA5.2.1 (e2,e8) DFA2.1.4 (e4) DFA2.1.5 (e5) DFA2.2.1 (e5) DFA4.1.7 (e9) DFA4.2.1 (e5) DFA5.1.1 (e2,e3) DFA5.1.3 (e6,e7) DFA5.1.4 (e5) DFA5.3.1 (e2) DFA5.3.2 (e2,e5) DFA5.3.3 (e2,e5) DFA5.4.5 (e6,e7)	MD2. (e3) MD4. (e1) MD5. (e2) MD6. (e7) MD7. (e6,e7) MD8. (e2) MD10. (e4,e5) MD11. (e4) MD13. (e2) MD15. (e1)	UU1. (e2) UU3. (e3) UU5. (e6,e7) UU6. (e7) UU7. (e1) UU8. (e2)	UD1d. (e1) UD3a. (e2) UD3d. (e2) UD3e. (e3) UD4a. (e4) UD4b. (e5) UD4c. (e5) UD4d. (e5) UD4e. (e5) UD5b. (e6) UD5c. (e7) UD6b. (e8) UD6c. (e8) UD6d. (e8) UD7c. (e9)	e1 e2 e3 e4 e5 e6 e7 e8 e9	Micro Environment – e
	DFA1.1.2 (E1) DFA4.2.3 (E1,E3) DFA4.2.4 (E1,E2)	DFA1.1.1 (E1) DFA2.1.5 (E3) DFA4.1.10 (E4)			UD7a. (E1) UD7b. (E2) UD7d. (E4)	E1 E2 E3 E4	Macro Environment-E

The final version of UDMIG 2.0 included all of the guidelines, either in whole or modified, from Universal Usability, Guidelines for handheld mobile device interface design, and Universal Design, whereas 4 of the 52 number of the guidelines in Design for Aging were excluded because of their application to desktops (See Table 4). As an example, half of the 8 UU guidelines (i.e., enable frequent users to use shortcuts, offer informative feedback, design dialogs to yield closure, and support internal locus of control) were included in whole as they apply to mobile devices. In contrast, the other

Table 4. Proportion of design guidance retained from each of the contributing sources

Design Guidelines Analyzed	Number of Guidelines	Number (%) of Guidelines Included in UDMIG 2.0	Number (%) of Guidelines Modified in UDMIG 2.0
Universal Design	30	30 (100%)	8 (26.7%)slightly modified
Design for Aging	52	48 (92.3%)	4 (7.7%) excluded
Universal Usability	8	8 (100%)	4 (50%) modified
Guidelines for handheld mobile device interface design	15	15 (100%)	0 (0%) modified

half of the guidelines (consistency, reversal of actions, error prevention and simple error handling, and reducing short-term memory load) was modified to fit the touchscreen mobile environment. In addition, 8 UD guidelines that cover low physical effort (Principle 6) and size and space for approach and use (Principle 7) were slightly modified to fit the mobile touchscreen environment.

3.2 UDMIG V.2.0

Resulting UDMIG v.2.0 grouped into Fit (F), Micro Environment (e), and Macro Environment (E) guidelines are presented bellow (See Table 5).

Table 5. UDMIG v.2.0

Fit Guidelines (F)	Micro Environment Guidelines (e)	Macro Environment Guidelines (E)
F1. Same means of use	**e1.** Design appealing to all	**E1.** Appropriate lighting and glare
F2. Range of literacy and language skills	**e2.** Simple and natural use	**E2.** Adjustable positioning
F3. Choice in methods of use	**e3.** Informative feedback	**E3.** Minimized background noise and reverberation
F4. Support of the internal locus of control	**e4.** Use of different modes	**E4.** Space for use of assistive devices
F5. Right-, left- or no-handed use	**e5.** Maximized "legibility" of essential information	
F6. Accuracy and precision	**e6.** Simple error handling	
F7. Adaptable pace	**e7.** Easy reversal of actions	
F8. Consistency with expectations and intuition	**e8.** Low physical effort	
F9. Dialogs that yield closure	**e9.** Variations in hand and grip size	
F10. Clear and understandable navigation structure		
F11. Multiple and dynamic contexts		
F12. Minimized hazards and unintended actions		
F13. Natural body position		

3.3 Application of UDMIG V.2.0

A voting ballot was designed using UDMIG 2.0 to integrate visual and audio output without any special adaptations [20]. EZ Ballot interface was designed to meet the guidelines for Fit (F), Micro Environment (e) and Macro Environment (E) as follows:

Fit Guidelines (F).

F1. **Same means of use**. Ballot interface comprises one voting system to all voters regardless of their abilities.

F2. **The range of literacy and language skills**. Universal and recognizable icons were used for text size, audio speed, and contrast; simple Y for Yes, N for No, and I for instructions, and video the instructions on how to use the ballot.
F3. **Choice in methods of use**. Multiple means of input (e.g., touch, stylus) and navigation methods (e.g., Yes/No touch buttons, scroll, and swipe gestures), and output characteristics, including visual (text size, contrast) and audio (speed, volume) were provided.
F4. **Support of the internal locus of control**. Choices of input and navigation methods, multiple visual (text size, contrast) and audio (speed, volume) characteristics, consistency in system navigation, and easy access to all the content (main control pane) were added to enable older adults feel that they are in control.
F5. **Right-, left- or no-handed use**. Inputs were made usable for right- or left-handed older adults by putting the navigation and touch buttons in places that were in natural locations that were easy to reach with either left of right fingers.
F6. **Accuracy and precision**. Large touch-buttons with enough space between the buttons minimize the need for accuracy and precision.
F7. **Adaptation to users' pace**. Ballot interface was designed to support any voter's pace with multiple audio speed options, linear and random access interfaces, and providing a choice for skipping instructions, any races or propositions.
F8. **Consistency with expectations**. The answer to the question on each page was Yes or No. Touchscreen buttons were designed to look touchable.
F9. **Dialogs that yield closure**. Ballot interface provided older adults with the satisfaction of accomplishment and completion, a sense of relief, and an indicator to prepare for the next group of actions.
F10. **Clear and understandable navigation structure**. The instruction was provided to guide on the use of and navigation through the interface, and Review was designed to take the voter to any particular point in the voting system so that older adults could have Clear and understandable navigation structure.
F11. **Multiple and dynamic contexts**. The default setting of the audio output was turned on.
F12. **Minimized hazards and unintended actions**. Yes and No touch buttons were located at the farther left and right sides of the touchscreen, and other touch buttons were placed on the main control panel. The UI began with instructions.
F13. **Natural body position**. Main input buttons were designed at the locations where older adults' hands are in neutral body position (Figs. 1, 2 and 3).

Micro Environment (e).

e1. **Design appealing to all**. Familiar design features were used, institutional appearance was avoided, and human voice was used as an audio sound.
e2. **Simple and natural use**. Guided linear or random access structure that matches the audio interface were provided, the piece-by-piece process broke down a complex task into several easy-to-complete subtasks to reduce complexity, visual clusters were removed, and multiple contest pages on one screen were avoided.
e3. **Informative feedback**. Two ways for verification, a prompt and a sub-review message were provided.

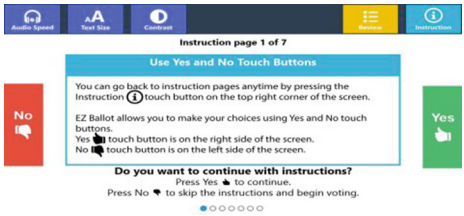

Fig. 1. Instruction page 1

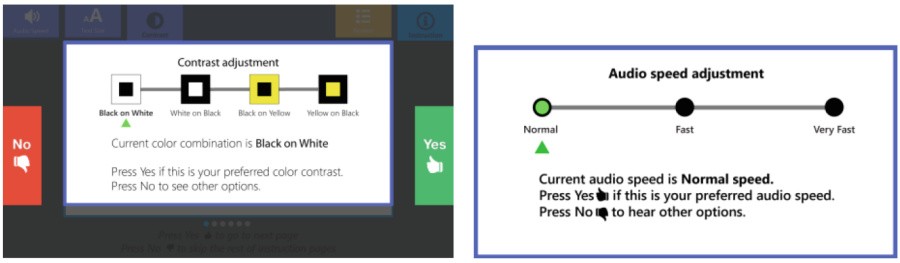

Fig. 2. Contrast (left) and audio speed adjustment (right) pages

Fig. 3. Ballot overview (left) and President and Vice-President selection (right) pages

e4. **Different modes of use**. Simultaneous visual and audio ballot interface and tactile indicators for locating the touch buttons were provided. Universal icons along with redundant cues (e.g., color, text, and symbols) were used.
e5. **Maximized "legibility" of essential information**. Information was displayed in sans serif and in at least two font sizes: 3.0–4.0 mm (the height of an upper case letter in the smaller text size) and 6.3–9.0 mm (the height of an upper case letter in the larger text size); based on the VVSG (Sect. 3.2.2.1.b.) recommendation. The page title was made bold.
e6. **Simple error handling**. The warnings (under voting, over voting) were designed to prevent mistakes during a voting process, with two ways for verification, a prompt and a sub-review message. Review and Instruction touch buttons were located on the main control panel to be easy to find while isolated from the most used Yes/No touch buttons.

e7. **Easy reversal of actions.** Review page provided easy reversal of actions.
e8. **Low physical effort**. The physical buttons were taken out and instead used large touch buttons, multiple actions (e.g., double tap, split-tap) were avoided, and a single tap was used, tactile icons were used to navigate the older adults' fingers to the location of the touch buttons to ensure Low physical effort.
e9. **Variations in hand and grip size**. Large touch buttons and large tactile icons on the cover of the screen, and sufficient space between buttons were designed for different size of fingers and grip (Fig. 4).

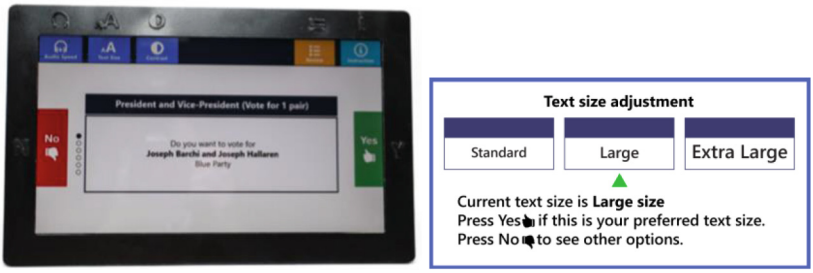

Fig. 4. Tactile cover (left) and text size adjustment page (right)

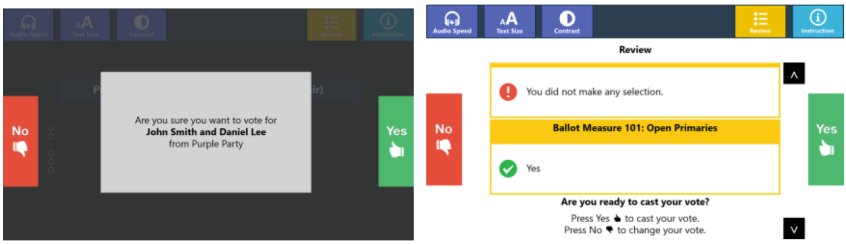

Fig. 5. A prompt message (left) and review page (right)

Macro Environment (E).

E1. **Appropriate lighting and glare**. Adjustable display and adequate lighting need to be provided at the voting poll.
E2. **Adjustable positioning**. Ensure adjustable height, depth, width, and angle from a seating position at the voting poll.
E3. **Minimized background noise and reverberation**. Wireless headphones should be provided to voters.
E4. **Space for the use of assistive devices** needs to be arranged at the voting poll (Fig. 5).

4 Discussion

Older adults as mobile technology users are in a need of user interfaces that fit their needs and abilities. While Universal Design, Universal Usability, and Guidelines for handheld mobile device interface design all guide design of interfaces, when placed in a context of designing interactive mobile user interfaces for older adults these were not found complete. Moreover, UU and UD guidelines were not originally developed for mobile interfaces. UD recently included this platform to a certain extent. In addition, Design for Aging focuses on older adults with their particular limitations usually associated with this end-user group, failing to acknowledge ranges and combinations of limitations older adults have. Adaptation and addition of some of the guidelines were necessary to accommodate design for the interactive mobile interfaces for older adults.

UDMIG v.2.0 are an inclusive and complete set of the guidelines developed to guide design process of interactive mobile interfaces for older adults. They are divided into three sets of guidelines: Fit (F), Micro (e) and Macro Environment (E). Fit Guidelines relate to the interaction between older adults and their environment, Micro Environment guidelines guide design of the touchscreen mobile interface, and Macro Environment guidelines help with the design of the space and context of use. Person component is present in all the guidelines, which all describe how to accommodate people with different abilities, and it was not used as a way of grouping the UDMIG.

The guidelines were based on the established strategies for desktop and mobile user interfaces for older adults and published research on interactive mobile interfaces and designing for aging population. Their significance is in their completeness, and integration of the four common strategies for designing interactive mobile interfaces for older adults. This unique set of the guidelines is useful to Human-Computer Interaction (HCI) researchers working in a field of usability and mobile user interface design as well as to industry leaders who develop mobile devices and applications for our aging population.

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